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Regional Research Laboratory, Thiruvananthapuram

A. D. Damodaran

Regional Research Laboratory, Trivandrum, a constituent unit of the CSIR, has as its charter the following objectives:

(i) Systematic input of science and engineering research on selected and important regional resources

(ii) Continued dissemination of this knowledge to professional and possible user agencies

(iii) Systematic transfer of the feasible technologies to existing or new industries, thereby contributing to further economic development

(iv) Training and professional support for augmenting the relevant manpower infrastructure.

Such a strategy of decentralized science and technology development to meet the specific needs of a region necessarily calls for detailed planning, serious mid-course corrections, and, more than anything else, multidisciplinary team efforts.

Based on detailed deliberations between CSIR and state-level agencies, RRL/T has been concentrating its research programmes in the following two important areas: selected plantation products of the region, and selected mineral products of the region. Whereas these two programmes encompass more than three-fourths of our research efforts, work is also carried out in certain well-recognized advanced materials like metal matrix composites and also frontier areas such as photochemistry. Within such a perspective the laboratory has established a multidisciplinary man-power-cum-equipment infrastructure.

Plantation products

Spices, oil-bearing fruits such as oil palm and coconut, and the regional starch source tapioca form the selected group of plantation products taken up for the laboratory programme. All these valuable crops are given agricultural research support by crop-specific ICAR laboratories and RRL/T collaborates with them on the following aspects:

1. Quality and standards
2. Post-harvest processing for value added products
3. Extraction and processing technologies
4. Possible development of biological pesticides and such special agrichemicals.
5. Basic research in support of the above programmes.

Thus the laboratory has carried out detailed quality evaluations of different varieties of cardamom for the Spices Board and similar quantitative studies are in progress for pepper, hopefully helping in the development of superior genotypes in a systematic and scientific manner. A number of new value-added products have been developed from these plantation products, some of which are on production and others on different stages of technology transfer. Indeed, over the years the percentage conversion of the raw materials to value-added specialized products would increase, thereby also increasing the foreign-exchange earnings. Among the notables new ones are shelf-stable coconut cream, encapsulated spice flavours and white berry pepper, totally free of pesticide residues.

A major work on extraction and processing, carried out under the Oil Mission programme, was the development and commissioning of a totally indigenous edible raw palm oil extraction plant at Palode near Trivandrum. This plant, to cater to a 200-hectare plantation area, is being used jointly with CPCRI/ICAR to demonstrate to Indian farmers the feasibility of taking up cultivation and production of palm oil to meet the growing needs of edible oil. With an estimated cost of production not exceeding Rs 8000 per tonne, this has wide economic possibilities. Larger-capacity plants are also under design to meet specific needs (Figure 1).

Post-harvest technology of tapioca forms the other important area of research activity. The scope of cultivating high-starch-containing tapioca varieties is being increasingly recognized in this region, thanks to the development and release of high-yielding varieties by CTCRI/ICAR. Such varieties give yields as high as 40 tonnes per hectare under optimum agricultural practices, with estimated production cost of Rs 300 per tonne—figures valid for Salem/Tamil Nadu. Obviously this valuable agricultural product must form the raw material for value-added fermented products. A process for conversion of tapioca starch to alcohol by a continuous-immobilization technique is under development as a futuristic technology and as a workhorse for detailed studies on immobilization, namely the techniques, reactor design, process kinetics, immobilized-cell behaviour, etc. Work is started to develop flowsheet for another valuable fermented product like beta-cyclodextrin based on indigenous strains.

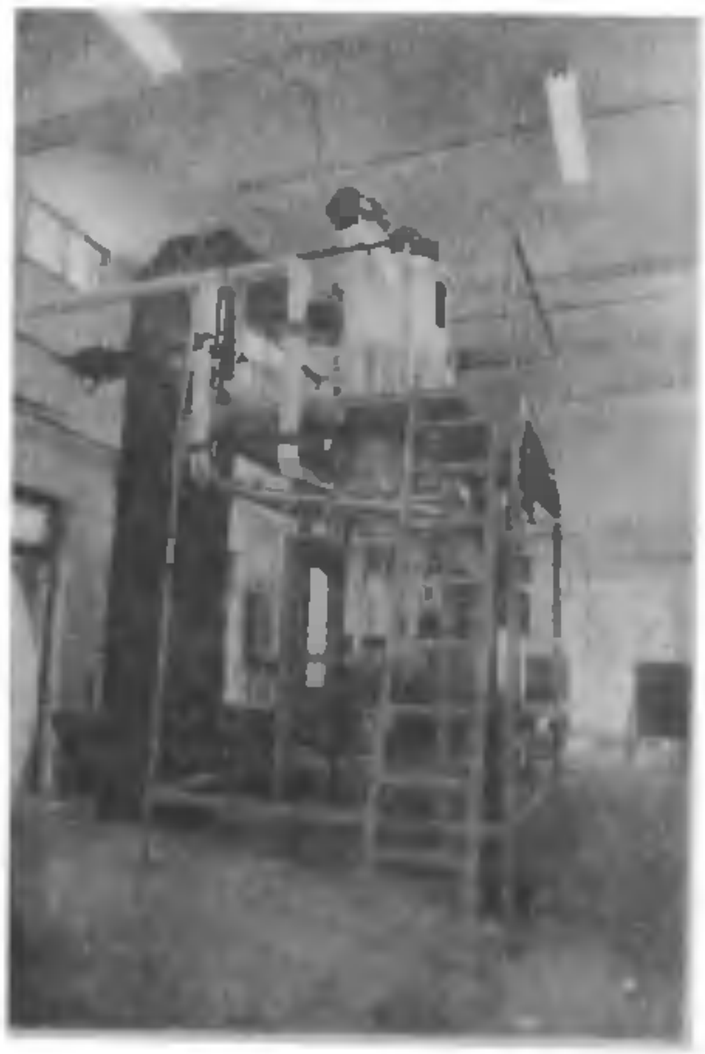

Figure 1. Palm oil extraction plant.

Development of appropriate biological pesticides have high significance, particularly for the high-cost plantation products like spices. As part of this speciality agrichemicals programme a pheromone compound is being field-tested for sweet potato jointly with CTCRI/ICAR. This is being extended for potato also. Systematic studies have been initiated to develop appropriate pheromones and antifeedants for spices like cardamom, ginger, turmeric and pepper with the avowed objective of avoiding use of pesticides for these exportable edible products (Figure 2).

Very important basic research programmes are also taken up on the chemistry of these plantation products. As part of the study on the chemistry of coconut, seven regions of coconut endosperm were separated for detailed investigation which revealed a marked concentration gradient for the various constituents. Basic studies on biotransformation in germinating coconut endosperm revealed that the haustorium, so far regarded as only an absorbing tissue without any active role, was found to be functional in nature. This is absent in other oil-bearing seeds. Detailed investigation on enzyme activity revealed maximum activity in haustorium and not in endosperm suggesting its active role in transformation during germination.

Roasting enhances the flavour of coconut tremendously. GC and GC–MS analysis of the flavour of compounds of heated coconut showed presence of 18 pyrazines in addition of beta-lactones, alcohols, esters, carbonyls, acids etc. already present. Pyrazines which impart

Figure 2. Pheromone field trials.

roasted flavours are formed during Maillard reaction between sugars and amino acids. Recently, processed flavourings of caramel, meat, coffee, cocoa, peanut, etc. are produced and marketed abroad. Development of such flavourings require exact knowledge of flavour compounds.

The laboratory has undertaken considerable amount of work on speciality polymers. It was found that appropriate functionalization and oligomerization give a prepolymer from CNSL having multpurpose applications such as use as a fire-retardant additive for plastics and elastomers, conversion to ablative polymers, as a matrix resin for brake linings, etc. Thus phosphorylated CNSL prepolymer names ANORIN-38 and a few related polymers were synthesized and characterized. ANORIN-38 was scaled up to 50-kg level in a batch process in collaboration with VSSC, Thiruvananthapuram, and the process is released to industry (Figure 3).

A carbon-fibre ablative polymer was prepared and was found to have superior properties compared with conventional phenolic ablatives. The synergistic fire-retardant combination developed for natural rubber was also found to have anti-ozonant properties which will considerably improve the weatherability of natural rubber. A sponsorship funding for Rs 12 lakhs has been obtained from DST for the speciality polymers development work in the laboratory.

Regional mineral materials

Among the regional mineral resources, clay and allied ceramic materials, rare earths and ilmenite have been identified for research programmes at RRL/T. Over the years work on ceramic materials has been consolidated fairly well whereas that related to extraction and processing of ilmenite and rare-earth resources have attained some reasonable level of expertise.

The laboratory programme on clays has given great thrust to industrially oriented problems. A monograph on Kerala clays was prepared based on systematic evaluation of their chemical composition, mineralogical properties, and firing and refractoriness characteristics. This study is proposed to be extended to clays of South India under support from Department of Mines. Such studies form the prerequisite for standardization of clay supplies and also valuable import substitution to produce clay mixes of tailor-made and specified properties. A process has been developed for purification of clay from graphitic impurities by froth flotation as a sponsored project from English India Clays Ltd (Figure 4). For the same company the laboratory has developed the process flow sheet for manufacture of zeolite 4A from kaolinite resources. Both these T/T are in progress. Some work has been also initiated on preparing pillared clays with specific inorganic oxide bridges with possible application as catalysts. Other products developed are: light-weight bricks using pith as the internal fuel and vitrified tiles from terracotta clays.

Among the nonnuclear beach mineral resources, ilmenite and rare earths are taken up for systematic studies, specifically dealing with extraction, separation and purification. A rather detailed computer program has been developed for mathematical modelling of liquid/liquid extraction and separation of individual rare earths by reagents like PC 88 from chloride medium with the specific objective of process optimization and possible use of the program for developing a computer-controlled process instrumentation system. Attempts are being made for synthesis of new reagents for extraction and also easier methods of analysis. Methods have been standardized for preparing individual high-purity rare-earth metals by pyrometallurgical procedures, e.g. Nd metal for conversion to iron–Nd–boron magnets. A few strategically important alloys are also under development. Addition of light rare-earth metals to aluminium alloys has given rise to improved mechanical properties like UTS and percentage elongation. Systematic work is undertaken on this exciting system for possible development of better-quality alloys for civilian uses.

HEH(EHP) is an effective reagent for the extraction of lanthanides. As on today, HEH(EHP) is not commercially synthesized in the country. A few trial studies were done for its synthesis. A series of experiments were carried out to improve the yield of HEH(EHP). Studies are being carried out for an alternative method for the synthesis of HEH(EHP).

Rare-earth based high-T_c materials form a separate and significant area of research. Important contributions are: preparation of 'oriented' powders, high quality powders through a modified citrate sol–gel route being fabricated to polycrystalline extruded wires having J_c values as high as 225 A cm^{-2} at zero field, and silver-sheathed wires with J_c values nearly 1200 A cm^{-2} at zero field, and so also related basic research resulting in a number of publications.

Beneficiation of Indian ilmenites, differing in their weathered properties, to synthetic rutile, again of different grades, is being studied systematically. A pilot plant flow sheet has been standardized for converting the former to the latter by a direct carbon reduction-cum-rusting process, which is being taken up

Figure 3. Scale-up trials on CNSL-based resins.

Figure 4. Flotation cell.

for T/T to industry. Concurrently work is also carried out to elucidate the kinetics and mechanism of this very interesting heterogeneous reaction. A project is nearing completion, on the request of a private company, to treat the effluents from the sulphate route-based titanium oxide plants, with the sulphate values being recovered as valuable fertilizer.

Under the programme of the laboratory in the effluent-engineering area, a process has been developed for treatment of waste water and reuse of treated waters generated by the natural rubber processing industry. Based on this process a plant of the capacity 75 m^3 per day has been successfully established at Hindustan Latex Ltd, a Government of India undertaking at Thiruvananthapuram. A similar plant has also been set up at their factory at Belgaum, Karnataka. The development and utilization of this process has resulted in a saving in foreign exchange to the tune of Rs 80 lakhs.

The technology for treatment of waste waters from natural rubber centrifuging factories was transferred to A. V. Thomas and Co. for project implementation. A project on recovery chemicals from titania effluent has been sponsored by Green Valley Chemicals. A flow sheet has been developed for setting up a large-scale plant in collaboration with engineering consultants. A programme on bioremediation of organic pollutants was initiated to study the problem associated with aerobic treatment of industrial waste waters.

Advanced materials

High-T_c ceramics and metal matrix composites form this group of special materials of great interest to the laboratory.

The casting route has been more or less standardized for preparation of these materials. The 'master alloy addition' concept has been extended for this process. Addition of Misch metal is found to enable incorporation of even 50 to 60% graphite into aluminium alloys, for which a patent has been filed.

An 8–10-kg rheocasting facility is being used for MMC synthesis incorporating also chopped carbon fibre as the dispersoid.

A complementary route for MMC processing through compocasting–liquid metallurgy–pressure die casting is developed. In this method the technique is to prepare the alloy by compocasting which is subsequently diluted to predetermined level by liquid metallurgy method and finally finished by pressure die casting. Composites with fairly uniform dispersion of graphite powders and silicon carbide fibres have been prepared by this technique. The cast components are also expected to have better mechanical properties compared with those made by other techniques. However, detailed studies are undertaken to evaluate this. As part of the ARDB-sponsored scheme, a procedure for fibre and particulate separation, combining chemical and ultrasonic treatment has been arrived at, which has facilitated uniform dispersion of second phase in the matrix.

The computer-modelling activity has been considerably expanded, particularly with respect to simulation studies in the areas of solidification phenomenon. A rigorous theoretical model has been developed for evaluation of critical velocity of any metal dispersoid system. Microgravity experiments for study of particle-front interaction and validation of the suggested model is envisaged. Also, a computer-simulation model has been developed for predicting microstructural evaluation in castings. A proposal for the same has been tentatively approved by ISRO (for experiments in the Mir Space station).

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